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MORTALITY OF DENDROCTONUS MONTICOLAE HOPK. LARVAE DUE TO LOW TEMPERATURES

Preliminary Report

by

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Preliminary Report

Low temperature tests were begun in the Forest Insect Laboratory at Stanford University, Calif., during the winter seasons of 1927 and 1928 by J.M. Miller, in connection with similar tests run on the western pine beetle. Not until the winter season of 1933 were freezing tests resumed to determine the temperatures fatal to D.monticolae broods.

The results of the first tests run on this beetle are summarized in this report by Miller as Test 1 of November 1927 and Test 2 of January 1928. The brood material used in the original tests was taken from areas in Oregon where temperatures below zero are a common occurrence during the winter months.

Tests 3 to 7 inclusive were conducted in the Forest Insect Laboratory, now located at the University of California, during January and February, 1933. The brood material used in Test 3 was taken from infested sugar pine logs collected November 1, 1932, in the central Sierra region near Base Lake, Calif., where air temperatures seldom reach 0° F. or below during the winter. The brood used in Tests 4 to 7 inclusive was taken from infested lodgepole pine logs collected in the northern Sierra region near Susanville, Calif., where temperatures of 0° F. or below occur frequently during the winter. All logs were placed in the open on the Oxford Street Tract at Berkeley, Calif., until tests were run. The brood remained in good condition.

This report is a summary of most significant data determined as a result of experiments to date. Important leads have been found which will be of value in further tests with this insect.

ORIGINAL TESTS

Dendroctonus monticolae in lodgepole pine

Mortality due to low temperatures

Test No. 1 Material collected in Crater National Park, October 1927, consisting of green logs infested by half-grown larval broods. These were kept in the laboratory at warm temperatures until November 14, when block sections of logs were rerun through temperatures in Frigidaire apparatus.

Date	Time	Temperature: Compartment	Log Section: Examined	Mortality aft. 3 da.: Live Lar.	Dead Lar.	Mortality %
11/14/27	9 a.m.	50°	Check	92	8	8
15	11 "	10	1	62	118	65
16	4 p.m.	-10	2	0	130	100
"	10 "	-16	3	0	all dead	100
17	3 "	3	4	0	" "	100
				(Cabinet warming back)		

Test No. 2 Lodgepole logs collected at Fort Klamath, Oreg., January 5, 1928. These were transported from field to laboratory and placed in freezing apparatus while broods were still dormant. Reported December temperatures at Fort Klamath were -15 while these broods had survived.

1/ 9/28	11 a.m.	50°	Check	94	6	6
"	1 p.m.	35	1	49	0	--
"	3 "	19	2	26	0	--
"	4 "	14	3	30	0	--
"	5 "	7	4	13	0	--
"	7 "	4	5	30	1	3
"	8 "	0	6	51	0	--
10	8:30	-5	7	23	10	3
11	1 p.m.	-10	8	25	20	44
"	3 "	-15	9	16	16	100
	5 "	-20	10	13	21	62

Records of tests made with naked larvae are not satisfactory. All larvae appeared to have been killed, however, when air temperatures reached 5°.

TESTS CONDUCTED AT BERKELEY, CALIFORNIA

Mortality of D.monticolae larvae exposed to air in open boxes

Test No. 3 D.m. larvae removed from infested sugar pine logs taken from central Sierra region near Bass Lake, Calif. All larvae divided into lots of 25 each in open boxes and exposed to low temperatures provided by Frigidaire compartments. Mercurial thermometers placed in open boxes with larvae to determine accurately the temperatures affecting larvae.

Date	Time	Temperature in Boxes	Lot #	Mortality aft.3 ds.: Live Lar.	Dead Lar.	Mortality %
1/10/33	11:50 a.m.	70°	Check	21	4	16
	2:40 p.m.	15	2	16	7	28
	3:30 "	10	3	9	16	64
	4:30 "	5	4	9	22	88
11	11:40 a.m.	0	5	0	25	100
	1:05 p.m.	-5	6	0	25	100
	3:05 "	-10	7	0	25	100
	7:00 "	-16	8	0	25	100

Test No. 4 D.m. larvae removed from infested lodgepole pine logs taken from northern Sierra region near Susanville, Calif. All larvae divided into lots of 25 each in open boxes, placed in refrigerator compartments with thermometers arranged as in Test No. 3.

1/17/33	10:30 a.m.	60°	Check	25	0	0
	1:15 p.m.	15	1	24	1	4
	1:45 "	10	2	25	0	0
	3:00 "	5	3	25	0	0
	4:15 "	0	4	19	6	24
	5:45 "	-5	5	11	14	56
	8:45 "	-10	6	10*	15	60
18	2:15 "	-15	7	0	25	100
19	3:20 "	-20	8	0	25	100

*Surviving larvae at -10° F. very sluggish

Test No. 5 Mortality of D.m. larvae after period of shocking, compared to unshocked larvae. The shocked larvae were placed in a Frigidaire compartment at 55° F., run down to 19.5° F., then removed to room temperature for 15½ hours; were replaced in compartment at 30° F. and run to 22° F.; replaced at room temperature for 4 hours, then in compartment at 25° F. and run to 19° F. to be left for 16¾ hours; replaced in room temperature 5¾ hours, then run down through temperatures below zero with a set of unshocked larvae. All larvae removed from infested lodgepole pine logs taken from northern Sierra region.

Set #1 - shocked larvae

Date	Time	Temperature in Boxes	Lot #	Mortality after 4 ds. Live Lar.	Dead Larvae	Mortality %
1/28/33	8:15 a.m.	70°	Check	25	0	0
	2:40 p.m.	15	2	25	0	0
	3:25 "	9	3	21	4	16
	4:15 "	5	4	20	5	20
	5:00 "	0	5	23	2	8
	7:10 "	-6	6	7	18	72
	9:30 "	-11	7	5	20	80
29	1:00 "	-15	8	0	25	100
	4:30 "	-20	9	0	25	100

Set #2 - unshocked larvae. Removed from infested lodgepole pine logs taken from northern Sierra region near Susanville, Calif. All larvae divided into lots of 25 each and run through low-temperature ranges with shocked larvae.

1/28/33	2:40 p.m.	14°	10	25	0	0
	3:25 "	10	11	25	0	0
	4:13 "	5	12	25	0	0
	5:00 "	1	13	22	3	12
	7:10 "	-4	14	18	7	28
	9:30 "	-9	15	0	25	100
29	2:30 "	-15	16	0	25	100
	6:45 "	-20	17	0	25	100

Mortality of D.monticolae larvae due to low temperatures under bark

Test No. 6 Small blocks 6"x8"x1½" thick were split from lodgepole pine logs containing brood of full-grown larvae, and placed in refrigerator compartments. Mercurial thermometers were inserted in the ends of each block so that the bulbs were firmly imbedded between bark and wood. Temperatures affecting the broods were accurately recorded. All brood material used in this test was taken from the northern Sierra region.

Date	Time	Temperature: Inner Bark	Block #	Mortality aft.3 ds.: Live Lar.	Dead Lar.	Mortality %
1/17/33	10:30 a.m.	Room				
	5:45 p.m.	15°	1	77	0	0
	7:45 "	8	2	46	3	6
	8:45 "	4	3	12	83	87
	10:15 "	-2	4	1	75	98
18	12:45 "	-5	5	5	94	94
	3:00 "	-10	6	0	96	100
	7:45 "	-15	7	0	107	100
19	4:30 "	-19.5	8, 9, 10	2*	283	99

Test No. 7 Small blocks 6"x8"x1½" thick, split from lodgepole logs containing brood of full-grown larvae. Two sets of 3 blocks each were used. The blocks in Set #1 were shocked for a period of two weeks by cooling to 20° F. and warming back to room temperature for periods corresponding to daily temperature fluctuations under natural conditions. The blocks used in Set #2 were placed in a constant temperature room at 45° F. for this period. Both sets were run down through temperatures below zero after the two weeks' period of preparation, and the mortality for each set compared. Brood material from northern Sierra region.

Set #1 - shocked larvae

Date	Time	Temperature: Inner Bark	Block #	Mortality aft.3 ds.: Live Lar.	Dead Lar.	Mortality %
2/28/33	9:00 a.m.	70	Check	69	1	1
	7:30 p.m.	-5	1	9	60	87
3/ 1	1:15 "	-10	2	0	75	100
	6:30 "	-15	3	0	72	100

Set #2 - unshocked larvae

2/28/33	7:30 p.m.	-5	4	1	35	97
3/ 1	2:45 "	-10	5	0	66	100
	6:30 "	-15	6	0	61	100

*Surviving larvae at -19.5 died after a period of two weeks.

Discussion

From the tests summed up in the foregoing pages, it is apparent that survival of D.monticolae broods when exposed to freezing temperatures is governed by the frequency and severity of low temperatures in the locality or region from which the brood was taken, and to a severe but gradual acclimatization to low temperatures before exposure to subzero temperatures. In Test 2 broods taken during December from Klamath Falls, Oreg., and later subjected to temperatures below zero, showed high survival. The exact temperatures affecting the broods in this test, however, were not known. At air temperature of -20° F. in the Frigidaire compartment survival of D. monticolae broods in the bark amounted to 58%. Since this material had previously been exposed to air temperatures reported to be -15° F., a certain amount of adjustment to winter temperatures would have taken place.

The results of tests run on naked larvae showed that broods taken from infested lodgepole near Susanville were more resistant to cold than D.monticolae broods taken from infested sugar pine in the central Sierra region. In Test #3 high mortality occurred at 5° F. and complete mortality at all temperatures below zero F. where naked D.m. larvae from sugar pine were used. Naked D.m. larvae from infested lodgepole pine survived temperatures as low as -10° F., but mortality was complete at all temperatures below -10° F., as shown by Test #4. In each case the broods were taken from the field before winter temperatures had set in, and were not able to become acclimatized to low temperatures before tests were run. In this case the region from which the brood was taken appears important, other factors being equal, causing cold-resistant strains.

Gradual acclimatization, due to periods of shocking, did not appear to be of great significance in Tests 5 and 7. Shocked larvae compared to unshocked larvae showed a somewhat higher survival to temperatures below zero, but further data are needed from field and laboratory tests to determine this point conclusively.

Larval mortality under the bark was found to be slightly higher than naked larvae when the temperatures affecting the larvae in each case were the same. In Test 6 heavy mortality occurred at 5° F., and in Tests 6 and 7 mortality was nearly complete at all temperatures below -5° F.

In general, the percentage survival of D.m. larvae from the Sierra region subjected to temperatures below -5° F. is small, and mortality is complete when the temperature falls below -10° F.